Mono- and multimodal green transport use on university trips during winter and summer: hybrid choice models on the norm-activation theory

Milad Mehdizadeh[a*], Mohsen Fallah Zavareh[b], Trond Nordfjaern[c]

a School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran.

b Kharazmi University, Department of Civil Engineering, Faculty of Engineering, Tehran, Iran.

c Norwegian University of Science and Technology (NTNU), Department of Psychology, Trondheim, Norway.

[*] **Corresponding author:** Milad Mehdizadeh, Email: milad_mehdizadeh@ymail.com; milad_mehdizadeh@civileng.iust.ac.ir (M. Mehdizadeh), Phone: (+98) 9365317045

Conflict of interest statement

The authors have no conflict of interest to report.

Financial disclosure

The study did not receive specific funding from any public or private agencies.

Abstract

The current study investigated the effects of environmental norms and beliefs as well as socioeconomic and situational characteristics on multimodal and monomodal green transport and car use on university trips during winter and summertime in Norway. Our major contribution to the state of the art is threefold: (1) we tested the norm-activation model (NAM) as well as demographic, socioeconomic and situational characteristics in explaining modality use through developing a hybrid choice model (HCM), (2) we explored the predictors of modality use among university students, and (3) we empirically investigated how, and to what extent, seasonal variation (winter versus summer) impacts on the link between the NAM theory and modality use. A cross-sectional self-administered survey was carried out in February 2019 at two of the largest university campuses in Trondheim, Norway (Dragvoll and Gløshaugen). Out of 419 questionnaires distributed among students, 316 valid observations were used for analysis. Findings showed that: (1) the NAM theory was associated with multimodal and monomodal green mode use in summertime, while this relation was not supported for wintertime, (2) most of the students in the current sample were green transport-oriented, and (3) situational factors such as accessibility to public transit and cycling time to university were more important for modality use during wintertime than summertime. Policymakers could implement measures so as to provide availability of all sustainable transport modes and routes, such as reliable and safe bicycle and walking paths, for all days during wintertime even during days with heavy snowfall in order to activate individuals' moral obligations towards reducing car use and modal shifts from car to green transport modes. Furthermore, encouraging students to be multimodal green transport users could be a feasible policy in order to reduce the probability of any shift from a green-oriented mode to the car, even in days with exceptional weather during the winter season.

Keywords: Modality use, Green transport use, Norm-activation model, Situational factors, Season, Hybrid choice model

1. Introduction

Single-use or occasional use of a car may cause traffic congestion, air pollution, health issues, and car use habit formation. Encouraging individuals to shift their travel mode use from car (either single or occasional use) to multimodal or monomodal green modes including active transportation modes (e.g. walking, cycling), public transit (e.g. bus, tram) and electric vehicles, can alleviate such problems. Multimodality refers to use of more than one travel mode during a given time period (Buehler and Hamre, 2013, 2015) e.g. during a specific weak, season, etc. In particular, studies have shown that multimodal car users, who drive and use at least one mode of transport other than car for their all trips during a specific time period (e.g. one week), have a potential to switch from car to green transport modes on some trips (Chlond, 2012; Molin et al., 2016). Meanwhile, it seems that compared to the multimodal green users who alternatively switch between different green modes of travel, those who frequently use a single green mode (monomodal green users) are less likely to be loyal to green mode use and may be more prone to shift to car use (Buehler and Hamre, 2013). In exceptional cases such as snowy days, for instance, for those to whom walking is the dominant mode of travel, they may switch to car use instead of other green modes. Therefore, a better understanding of modality styles concerning monomodal and multimodal car use or green transport use can give important insights which could be incorporated into policy measures.

Switching car use to green modes of transport has been on the agenda both among policy developers and authorities in recent years. Besides the demographic, socioeconomic, built environment and spatial characteristics (Cervero et al., 2009), individuals' norms and beliefs have also been recognized as crucial psychological factors associated with pro-environmental mode use behaviour (Steg and Vlek, 2009). In psychology, the Norm-Activation Model (NAM) is one of the most utilized and still alive theoretical frameworks, which investigates a causal structural relationship in explaining sustainable behaviour (Schwartz, 1977; De Groot et al., 2008; Huijts et al., 2013; Møller et al., 2018; Mehdizadeh et al., 2019). The NAM includes three factors: (1) awareness of consequences (AC), (2) ascription of responsibility (AR), and (3) personal norms (PN). The theory argues a causal structural chain which ultimately activates an individual's pro-environmental behaviour. Specifically, the AC factor refers to that individuals realize the adverse environmental consequences of their behaviour, such as using a gasoline-based car. This factor has been assumed to predict AR, which refers to that the individuals perceive themselves to be personally responsible for the consequences of their behaviour. Finally, AR predicts PN, which refers to that the individuals perceive a personal moral obligation to take action for the benefits of the collective (Schwartz, 1977; De Groot and Steg, 2008; Lind et al., 2015; Nordfjaern and Zavareh, 2017; Mehdizadeh et al., 2019).

Despite the importance of promoting pro-environmental travel behaviours, however, little is known about how the NAM theory can influence multimodal and monomodal transport in university trips, particularly among university students. There are three reasons for why it is important to focus on this group in mode choice research. First, because of a difference in socio-economic characteristics, university students may exhibit a difference in their travel behaviour, compared to the general population. As a social group, with considerable freedom in the campus environment, students tend to have complex and unique travel patterns (Limanond et al., 2011). For instance, their travel mode choice might be substantially affected by their peers. Second, transport to/from the university constitutes an essential and large share of the total daily trips in most cities (Danaf et al., 2014; Khattak, 2011; Nordfjaern et al., 2019). Such repeated and mandatory urban trips among the university students as a young segment of the population may potentially shape the habitual use of a similar travel modality in the future, when they become older (Verplanken, Aarts, and Van Knippenberg 1997; Verplanken and Orbell 2003; Muromachi 2017). Hence, influencing modality patterns among university students could have ramifications for urban mode use in the upcoming decades. Third, modal use variability among university students often includes a higher share of different types of modes compared to the general population (Diana, 2008; Whalen et al., 2013), displaying a higher chance of modal shift between different green transportation options.

Apart from this, there is less knowledge about how pro-environmental theories can explain modality use in countries with differing situational characteristics during wintertime and summertime. Norway is an example of such a context, with large temperature differences between summer and winter, often with snowy conditions during the latter season. Fyhri and Hjorthol (2009), for instance, reported that the major seasonal difference in schoolchildren mode use in Norway was manifested by increased walking and less cycling in the winter compared to summer. In addition, a study in the United States revealed that millennials had a much lower tendency to use the car in the winter than the summer, whereas seasonality had little influence on the propensity of non-millennials to use car (Hyland et al., 2018). In spite of these findings, however, it is not clear how and to what extent environmental norms and beliefs, as well as situational characteristics, relate to modality use of university students in countries with distinct seasonal differences, such as Norway.

Considering the preceding arguments, the research questions of the present study were as follows: (1) how does the NAM associate with multimodal and monomodal green transport use among university students? (2) Does this theoretical framework predict multimodal and monomodal use in wintertime and summertime? Meanwhile, our contribution to the state of art is threefold: (1) we tested the norm-activation model (NAM) as well as demographic, socioeconomic and situational characteristics in explaining modality use through developing a hybrid choice model (HCM) in an integrated framework. We developed an HCM aimed at incorporating several latent psychological variables (either as independent or mediating variables), in addition to the observed variables, into a discrete choice model (Ben-Akiva et al., 2002), of modality use, (2) although the multimodality and monomodality have been examined both in the general population and among school children, there is less knowledge about monomodal and multimodal behaviour among students on university trips. Thus, we explored predictors of modality use among university students, and (3) we empirically investigated how, and to what extent, seasonality (winter versus summer) had an effect on the link between the NAM and modality use.

2. Literature review

Demographic variables (e.g. age and gender), socioeconomic variables (e.g. car ownership status, household size), built environment characteristics (e.g. distance, accessibility to public transit), and psychological factors such as attitudes and safety perception have been reported as significant predictors of multimodal and monomodal transport use. While most studies showed that females are more likely to be multimodal users (Mehdizadeh et al., 2018; Scheiner et al. 2016; Heinen and Chatterjee, 2015), some studies also found that males tend to be multimodal users (Buehler and Hamre, 2015; Nobis 2007). Older individuals were shown to be more likely to be monomodal users (Molin et al., 2016; Buehler and Hamre, 2016). In addition, Buehler and Hamre (2015) reported that adolescents were more likely to use monomodal transport modes (walking, cycling, or public transport). Concerning socioeconomic factors, Heinen and Chatterjee (2015) demonstrated that high income was associated with more modal variability. Households with a higher number of individuals were shown to be more likely monomodal users, especially car users (Mehdizadeh and Ermagun, 2018; Nobis 2007). Furthermore, those who had access to private cars tended to use less multimodal green transport (Buehler and Hamre, 2016; Heinen and Chatterjee, 2015; Buehler and Hamre, 2015; Diana and Mokhtarian, 2009). Some studies, however, found that car ownership was positively related to multimodal use (Molin et al., 2016; Kuhnimhof et al., 2012). In terms of situational factors, most studies reported that those who had access to public transit were more likely to use multimodal transport (e.g. Buehler and Hamre 2016; Heinen and Chatterjee 2015). Mehdizadeh and Ermagun (2018) found that a longer walking distance was negatively related to multimodal car use. Moreover, recent studies investigated the role of attitudes and intention on multimodality (Molin et al. 2016; Mehdizadeh and Ermagun, 2018). For instance, Molin et al. (2016) reported that favourable attitudes towards car were related to more use of car. In addition, Mehdizadeh and Ermagun (2018) found that favourable attitudes towards walking and safety were associated with more monomodal green transport use.

Although there has been a growing interest in examining attitudes, subjective norms, and intentions (e.g. Thorhauge et al., 2017; Cherchi, 2017; Kim et al., 2017) through well-established psychological theories (e.g. Ajzen, 1991) in relation to transport behaviour (), there is less knowledge about a framework which investigates pro-environmental behaviour in transportation.

The norm-activation model (NAM) was developed by Schwartz (1977), concentrating on factors resulting in altruistic behaviour reflecting that people give up personal interests to achieve environmental benefits (Schwartz, 1977; Schwartz and Howard, 1981; Huijts et al., 2013; Møller et al., 2018). Although it has been reported that the NAM components can successfully explain pro-environmental behaviour such as prosocial behaviour (Joireman et al., 2001), energy conservation (Tyler et al., 1982), recycling (Bratt, 1999; Guagnano, Dietz and Stern, 1994), reducing car use (Bamberg & Schmidt, 2003; De Groot et al., 2008; Nordlund & Garvill, 2003), and also recently sustainable travel mode choice among the general public (Jakovcevic & Steg, 2013; Lind et al., 2015), there is less knowledge about how the NAM causal chain can influence travel mode choice among young adults, especially their modality use.

Lind et al. (2015) examined the direct effects of the NAM dimensions in explaining sustainable transport mode use among Norwegians (see also Simsekoglu and Klöckner, 2018; Simsekoglu, 2018). De Groot et al. (2008) tested the link between this theory and acceptability of transport policies in the Netherlands. More recently, Ünal et al. (2019) showed that the behavioural link between environmental beliefs and car use reduction policies was supported in Russia. In addition to studies in Europe, Abrahamse et al. (2009) and Hiratsuka et al. (2018) examined the NAM relationship with reduction in car use and sustainable transport mode use in Argentina and Japan, respectively. Despite these observations, studies in China (Nordfjaern and Zavareh, 2017) and Iran (Mehdizadeh et al., 2019) have found that the NAM theory did not significantly associate with sustainable transport mode choice. These two studies concluded that such findings might be related to the study population (schoolchildren versus the general public), availability of sustainable transport options in the context of the two countries, situational characteristics, and cultural differences between eastern and western nations.

Previous studies have been prone to limitations as follows. First, they did not examine the simultaneous effects of socio-demographic, situational characteristics, and the NAM in an integrated analysis. To the best knowledge of the authors, no previous research has investigated the link between the NAM theory and modal choice considering both a latent variable model part and a discrete choice model part, simultaneously in an integrated framework (i.e. HCM). The HCM-analysis, however, allows investigating simultaneous effects of latent variables and observable variables on the choice from a set of specific alternatives (Ben-Akiva et al., 2002; Cherchi et al., 2013). Therefore, we extended the relationship between the NAM theory and pro-environmental behaviour by incorporating background characteristics (i.e. demographic, socioeconomic, and situational) as correlates of the NAM components, as well as modal choice. In the HCM-analysis, the NAM components (AC, AR, and PN) have also been tested as mediators between background variables and modality choice. Second, only very few studies have investigated multimodal and monomodal transport use among university students. Most studies have focused on either the general public (e.g. Diana and Mokhtarian, 2009; Molin et al. 2016) or school trips (Mehdizadeh and Ermagun, 2018). In the current study, we explored predictors of modality use among university students. Finally, the potential seasonal differences of the link between the NAM and modality use has not yet been widely reflected within the literature. We examined the stability of our hypothesized framework in winter and summer in order to explore the potential impacts of seasonal variation in individuals' modality.

3. Conceptual framework

According to the NAM theory and the study objectives, the conceptual modeling framework of the current study is shown in Fig 1. The framework tests whether the NAM causal chain influences modality use. In addition, the indirect effects of background variables (i.e. demographic, socioeconomic and situational attributes) on modality use have been tested through the NAM components (AC, AR, and PN as mediators), as well as their direct effects.

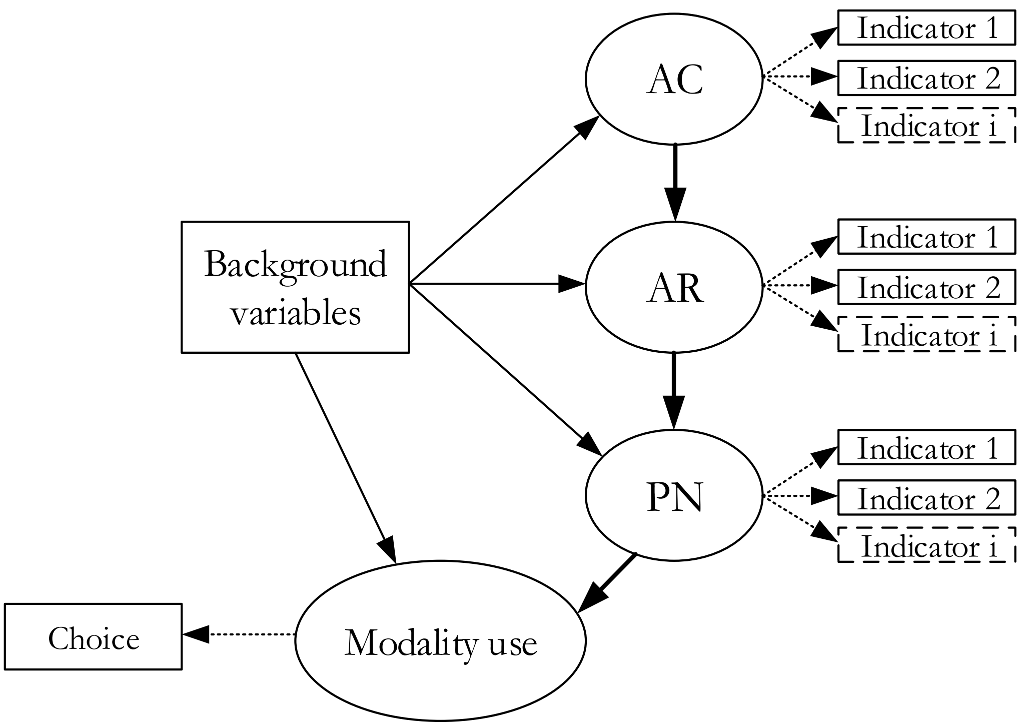


Fig 1. The conceptual model framework of the current study

4. Data

4.1. Sampling procedure

A cross-sectional self-administered survey was carried out in February 2019 at the two largest university campuses in Trondheim, Norway (Dragvoll and Gløshaugen). Sixty psychology students were affiliated with the project and carried out the data collection. These assistants were divided into eight groups consisting of 5–8 persons each. The respondents were recruited on the campuses during regular office hours 09.00 – 15.00. Gender, estimated age and reasons for non-participation were registered for non-respondents. Voluntary participation, secure data storage, and confidentiality of the anonymous responses were underlined to all potential respondents. In addition to campus recruitment, respondents were also recruited during two lectures. The students received oral information about the study and completed the questionnaires in the lecture break. The pooled response rate for campus recruitment was 67% and 60% for the lectures. Out of 419 questionnaires distributed among students, 316 valid observations were used for further analysis. There were no substantial differences between respondents and non-respondents in gender ($\chi^2 = 2.69$, df = 1, n.s.) and age (t = -1.14, df = 381, n.s.). Common reasons for a non-response were that the students were on their way to a lecture and did not have time available to the survey.

4.1. Questionnaire and measurement instruments

The questionnaire had several parts including (1) mode use during wintertime and summertime, (2) the NAM instrument, and (3) background (i.e. demographic, socioeconomic, and situational) attributes.

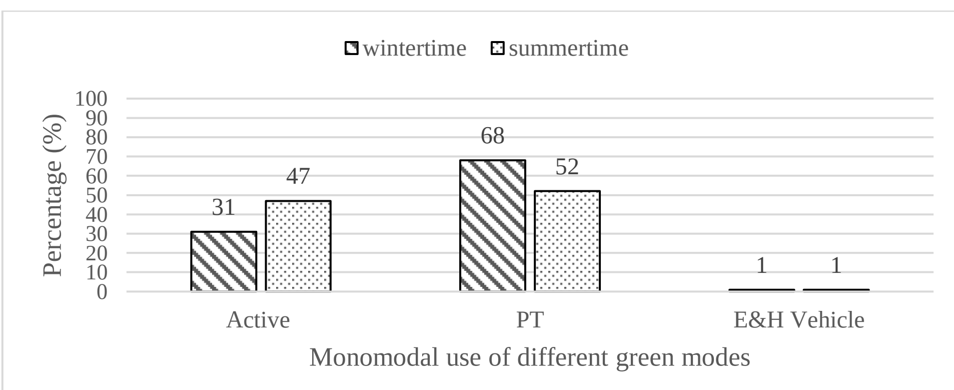
4.2.1. Mode use and modality classification

As the study aimed to investigate multimodality among university students during winter and summertime, we asked students: "how frequently do you use each of the following transportation modes during a typical week when traveling to and from the university?". The battery was presented separately for the winter (November through March) and summer seasons (April through August). The following transport modes were listed: walking, jogging/running, train, bus, bicycling (non-electric), electric bicycle, scooter/moped, motorcycle, gasoline- or diesel-based car as a driver, gasoline- or diesel-based car as a passenger, electric car as a driver, and electric car as a passenger. The measure was recorded on a Likert scale ranging from (0) never to (5) five days or more in a week.

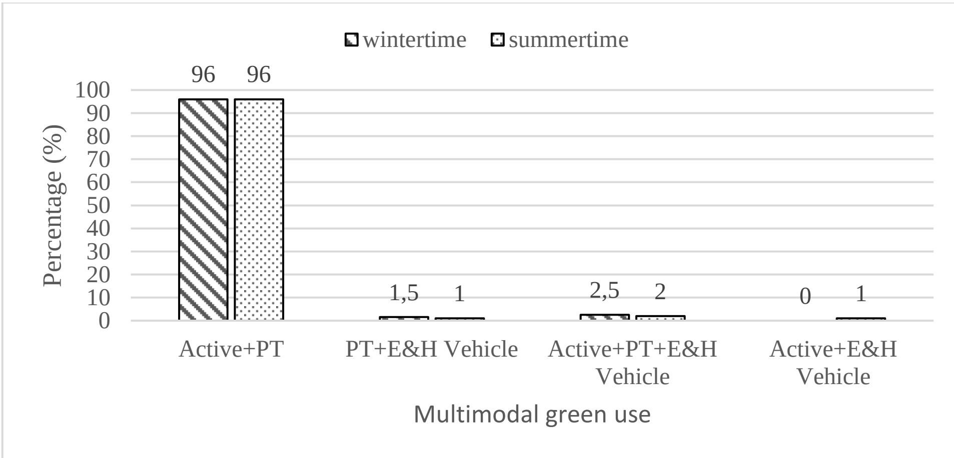
As the aim of the current study was to investigate predictors of modality use with respect to green transport mode and gasoline or diesel based use, similarly to the operationalization of multimodality and monomodality in previous work (Buehler and Hamre,2013, 2015; Mehdizadeh and Ermagun, 2018), mode use was classified into the three following modal groups by filtering and looking at modality use patterns in the data: (1) multimodal car users, who drive (or are driven) and u se at least one mode of green transport for their trips to/from university during winter/summer, (2) monomodal green users, who only (or exclusively) rely on each of the green modes including active modes (walking, jogging/running, bicycling, scooter/moped), public transit (train, bus), and electric/hybrid vehicles during winter/summer, and (3) multimodal green users, who use a combination of at least two distinct modes of green transport. Of note, an initial analysis on mode use data revealed that monomodal car users, who exclusively drive (or are driven) to/from the university for their all trips during winter/summer had a very low share (less than 2%) compared to the other modality groups. This is in line with previous research, which showed that measuring modality of an individual in a larger time interval (e.g. one season instead of one week) decreases the probability of being a monomodal car user (Mehdizadeh and Ermagun, 2018).

Although the overall share (at an aggregated level) of the three modality groups across winter and summer are somehow similar together, around 29% of the respondents (at a disaggregated level) reported that they alter their modality use in summer compared to winter. A closer look at the data at an aggregated level indicated that 61% and 62% of students were monomodal green transport users in winter and summer, respectively. Moreover, 28% and 26% of them reported to be multimodal green mode users in winter and summer, respectively. Meanwhile, the share of multimodal car use was around 11% for both seasons.

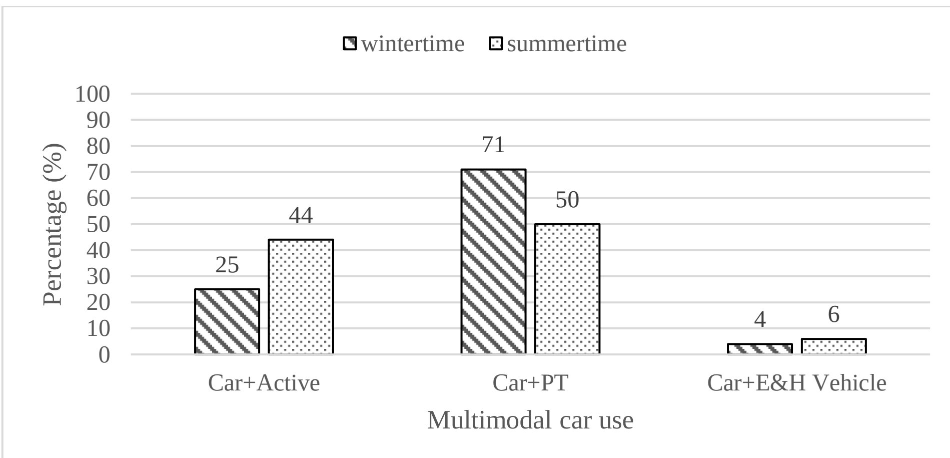
As shown in Fig 2.a, it is evident that among respondents who reported monomodal use of green transport modes, around 31%, and 47% exclusively walk to and from the university during winter and summer, respectively, while 68% and 52% only use public transit in winter and summer, respectively. As displayed in Fig 2.b, it is clear that most of the students (about 96%), who are falling into the multimodal green transport group, use the combination of active modes and public transit either in winter or summer. In addition, Fig 2.c illustrates different combinations of multimodal car users. It is evident that the mixed use of public transit and car is more common in wintertime.



a) Share of monomodal use of green modes in winter and summer



b) Share of multimodal use of green modes in winter and summer



c) Share of multimodal use of car in winter and summer

Fig 2. Share of modal groups in winter and summer (PT: public transit, E&H: electric and hybrid)

4.2.2. The NAM instrument

In order to measure students' environmental norms and beliefs, a validated instrument of the norm-activation model (NAM) was used (De Groot et al., 2008; Lind et al., 2015; Mehdizadeh et al., 2019). The original version of the NAM had 19 items, aimed to cover the AC, AR, and PN components in the theory. These items were scored on a five-point Likert scale ranging from (1) "completely disagree" to (5) "completely agree". This measurement included eight items about PN, such as "I feel morally obliged to use the car as little as possible, regardless of what other people do", and "I would be a better person if I more often used other transport modes instead of the car". Items associated with PN covered moral and personal obligation to either reduce car use or increase green mode use.

AR contained six items such as “I am jointly responsible for the problems caused by car use” and “I feel joint responsibility for the contribution of car traffic to global warming”. The AC dimension also included five items such as “Car use takes up a lot of space resulting in less space for cyclists, pedestrians and children” and “By reducing car use the level of air pollution will decrease”. These measures were tested and validated in previous studies, examining pro-environmental behaviour and transport mode use among the general public (Abrahamse et al., 2009; De Groot et al., 2008; Jakovcevic & Steg, 2013; Lind et al., 2015; Nordfjaern & Rundmo, 2015) and schoolchildren (Mehdizadeh et al., 2019; Nordfjaern and Fallah, 2017).

4.2.3. Background variables

The questionnaire also included items regarding each respondent’s age, gender, driving license status, and car and bike ownership. In addition, information was obtained about situational characteristics including perceived walking time from residence to nearest public transit station for university travel (*PWT_PT*), perceived walking time from residence to university (*PWT_U*), and perceived cycling time from residence to university (*PCT_U*). Table 1 shows descriptive statistics of variables tested for further analyses.

Table 1. Definition and descriptive statistics for explanatory variables tested in the current study

Variable	Descriptive	Mean (SD)
AGE	Respondent’s age; a continuous variable ranging from 19 to 36	22.9 (2.6)
AGE_1922	1: Age of [19–22], 0: Otherwise	0.5 (0.5)
AGE_2336	1: Age of [23–36], 0: Otherwise	0.5 (0.5)
MALE	1: the respondent is a male; 0: otherwise	0.4 (0.5)
FEMALE	1: the respondent is a female; 0: otherwise	0.6 (0.5)
LICENSE	1: the respondent has a driving license; 0: otherwise	0.8 (0.3)
CAR_OWN	1: the respondent owns at least one car; 0: otherwise	0.2 (0.4)
BIKE_OWN	1: the respondent owns at least one bike; 0: otherwise	0.7 (0.4)
PWT_PT	Perceived walking time to nearest public transit station (min.)	4.5 (4.6)
PWT_PT_05	1: perceived walking time to the nearest public transit station is less than 5 minutes; 0: otherwise	0.6 (0.5)
PWT_PT_5+	1: perceived walking time to the nearest public transit station is 5 and more than 5 minutes; 0: otherwise	0.4 (0.5)
PWT_U	Perceived walking time to university (Min.)	23.7 (14.4)
PWT_U_010	1: perceived walking time to university is less than 10 minutes; 0: otherwise	0.1 (0.3)
PWT_U_1020	1: perceived walking time to university is between 10 and 20 minutes; 0: otherwise	0.2 (0.4)
PWT_U_2030	1: perceived walking time to university is between 20 and 30 minutes; 0: otherwise	0.6 (0.5)
PWT_U_30+	1: perceived walking time to university is more than 30 minutes; 0: otherwise	0.4 (0.5)
PCT_U	Perceived cycling time to university (Min.)	18.3 (13.4)
PCT_U_010	1: perceived cycling time to university is less than 10 minutes; 0: otherwise	0.3 (0.4)
PCT_U_1020	1: perceived cycling time to university is between 10 and 20 minutes; 0: otherwise	0.3 (0.4)
PCT_U_20+	1: perceived cycling time to university is more than 20 minutes; 0: otherwise	0.4 (0.5)
AC	The first dimension of the NAM; awareness of consequences	3.9 (0.6)
AR	The second dimension of the NAM; ascription of responsibility	3.0 (0.9)
PN	The third dimension of the NAM; personal norm	3.2 (0.8)

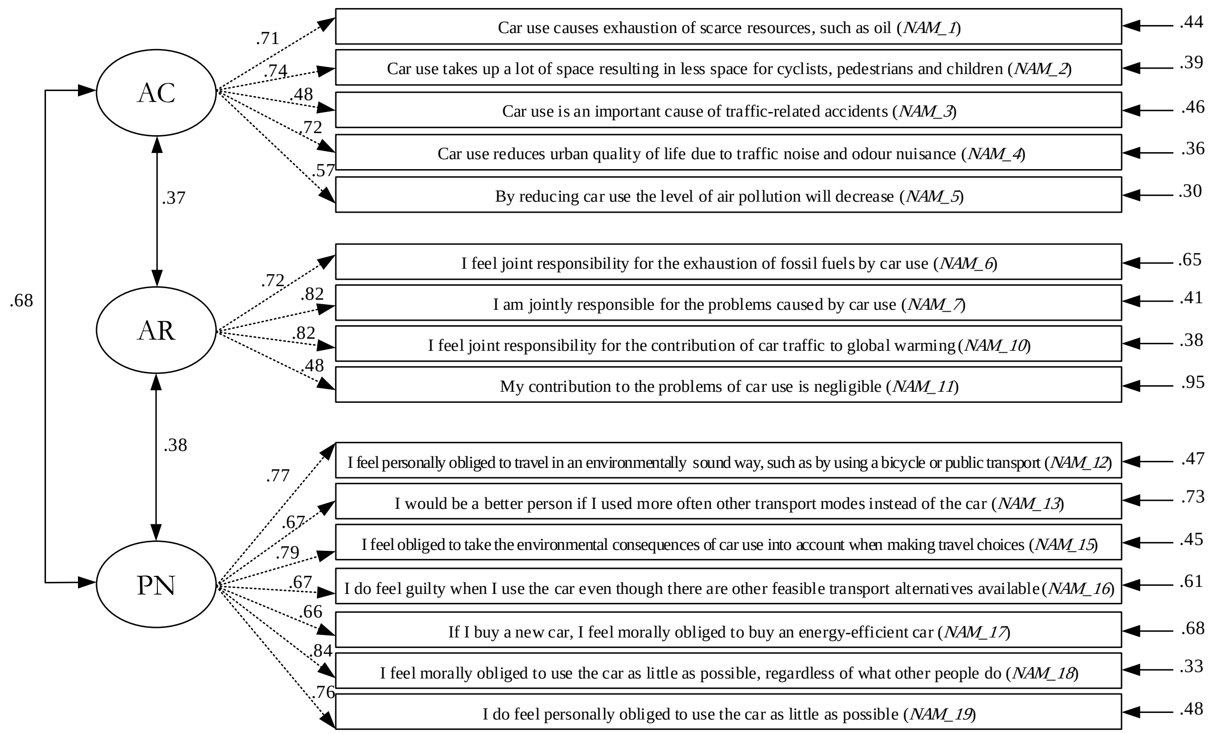
5. Modeling approach

We simultaneously tested the influence of different latent psychological factors covering the NAM theory as well as different observed background variables on the choice of modal groups. To do this, we developed a hybrid choice model (HCM). An HCM-analysis has two main parts, including a discrete choice part and a latent variable model part. The latent variable model part tests a pre-specified measurement model suggesting hypothetical relationships between the underlying latent variables and their indicators. A discrete choice model is simultaneously estimated together with the latent variable model in an integrated framework.

3.1. Factor analysis

In order to identify the hypothetical relationships or the underlying structures among the measured variables, an exploratory factor analysis (EFA) is usually used (Kim et al. 2017). Since the NAM measures applied in the current study have been widely validated and used in previous research, we applied a confirmatory factor analysis (CFA) to examine the conformity of the data with a three-factor structure that was previously identified in the literature. The Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) were applied as fit indices to determine the fit of the NAM measurement to the specified model (Kline, 2015). RMSEA values below 0.06 (Hu and Bentler, 1999), and CFI and TLI values between 0.90 and 0.95 reflect adequate model fit (Kim & Bentler, 2006). The chi-square (χ^2) with corresponding significance level was also reported. In addition, Cronbach's α (alpha) was calculated to test scale reliability and internal consistency of latent factors.

The results of a CFA conducted on the measures of NAM are reported in Fig 2. In accordance with the literature, this analysis confirmed that a three-factor solution had acceptable fit to the data (χ^2= 358.90, df= 101, $p< 0.001$, RMSEA= 0.057, CFI= 0.91, TLI= 0.90). Three items were removed because they failed to load consistently and did not have significant factor loadings in the CFA. These items were therefore removed from the measurement model. The excluded items were: "Not just others, like the government, are responsible for heavy traffic, but me too (*NAM_8*)" and "In principle, one person cannot decrease the problems of car use (*NAM_9*)" assumed to load on the AR factor, "People like me should do whatever they can to minimize their car use" assumed to load on the PN factor (*NAM_14*). After removing those items, Cronbach's α confirmed a satisfactory reliability for all three factors: AC (α=0.78), AR (α=0.80), and PN (α=0.89).



Standardized coefficients, significant p < .001 coefficients in bold

χ^2= 358.90, df= 101, p< 0.001, RMSEA= 0.057, CFI= 0.91, TLI= 0.90

Fig 3. Confirmatory factor analysis (CFA) of the NAM

3.2. The HCM

According to the conceptual modeling framework in Fig 1, the final estimated HCM structure is presented in Fig 4. The utility of modal groups is a function of latent and observable variables either directly or indirectly. The utility function (U_{nj}) can be expressed as Eq. 1:

$$U_{nj} = ASC_j + \beta_j SE_n + \theta_j ST_n + \lambda_{jz} LV_{nz} + \varepsilon_{nj} \tag{1}$$

where,

U_{nj}: the utility that individual n is associated with the modal groups j.

ASC_j: the vector of constants specific for $J-1$ modal groups.

SE_n: a vector of socioeconomic variables (β_j is the respective vectors of unknown parameters).

ST_n: a vector of situational characteristics (θ_j is the respective parameters).

LV_{nz}: z^th^ latent variable (λ_{jz} is the respective coefficients).

ε_{nj}: error term that is assumed to be identically and independently distributed (IID) extreme value type 1.

The latent variables are defined by a set of Z structural equations expressed as Eq. 2:

$$LV_{nz} = \alpha_z SE'_n + \sum_{m \neq z} \vartheta_m LV_{nm} + \omega_{nz} \quad \forall z, m \in Z \tag{2}$$

where,

LV_{nz} and LV_{nm} : are the latent variables z and m for the individual n.

SE' : is a vector of individual and family socioeconomic variables associated with z^{th} latent variable (α_z is the corresponding vector of coefficients.).

ϑ_m : is a coefficient associated with the latent variable m that hierarchically relates to the latent variable z.

ω_{nz} : is a normally distributed error term with zero mean and standard deviation σ_{wz}.

The indicator of latent variables as the measurement equation is expressed as Eq. 3:

$$I_{nkz} = \gamma_{kz} + \zeta_z LV_{nz} + \upsilon_{nkz}, \quad k = 1, \ldots, K \tag{3}$$

where,

I_{nkz} : is the kth indicator for zth latent variable.

γ_{kz} : is the constant in the measurement equations for indicator k of the latent variable z.

ζ_z : is the coefficient associated with the latent variable.

υ_{nkz} : indicates a normally distributed error term with zero mean and standard deviation $\sigma_{\upsilon z}$.

γ and ζ : are normalized to zero and one for the first indicator of each latent variable for identification purposes.

According to the random utility maximization theory, the choice model part is given by Eq. 4:

$$y_{in} = \begin{cases} 1, & if \;\; U_i = Max_j \left(U_{jn} \right) \\ 0, & otherwise \end{cases} \tag{4}$$

where,

y_{in} : is the choice indicator, taking the value 1 if modality group i is chosen (i has the highest utility among all modality groups in the choice set), and takes the value of 0, otherwise.

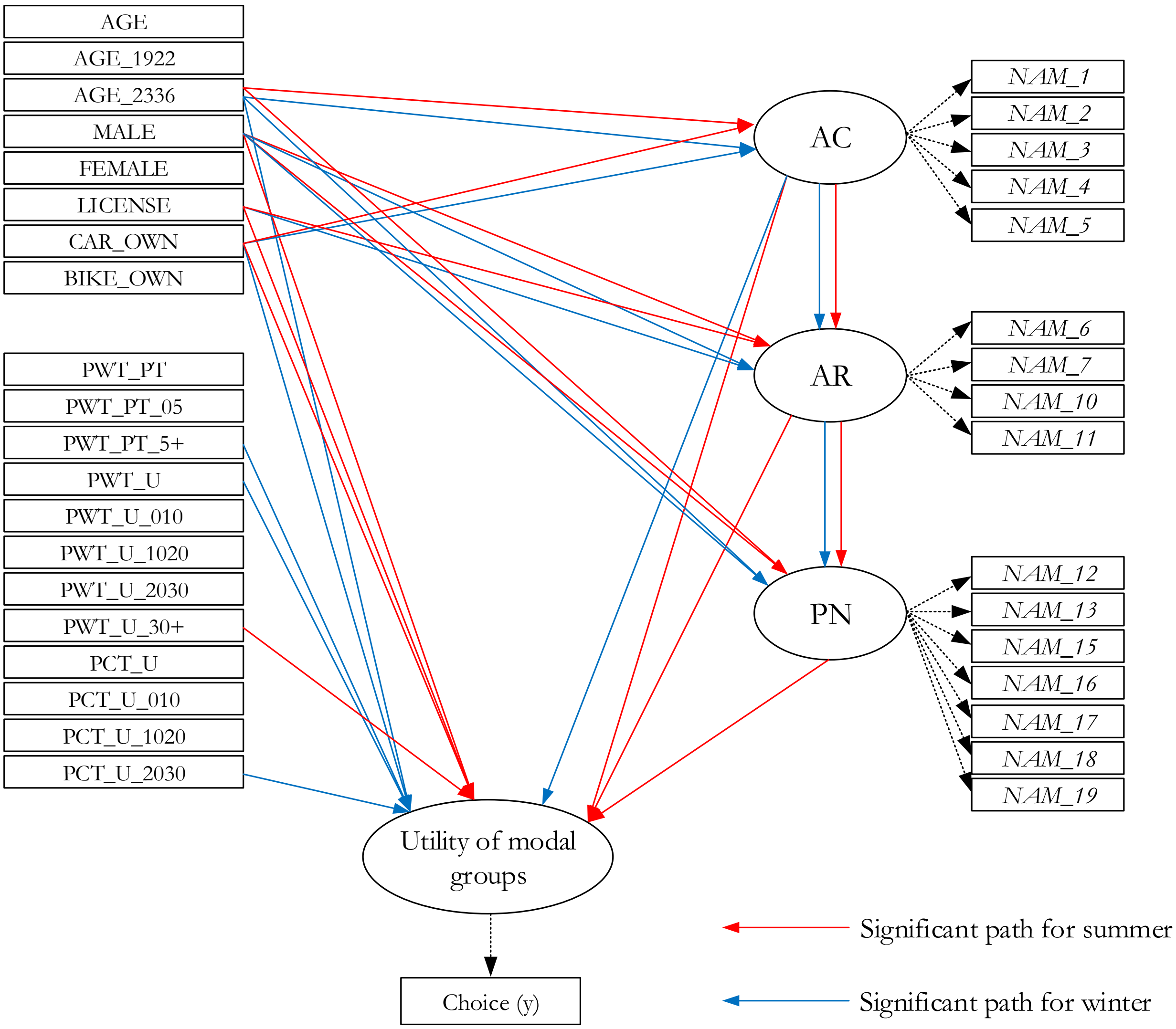


Fig 4. The estimated HCM-frameworks

Equations 5 and 6 are used for the distribution of the latent variable and the indicators:

$$f_{LV}\left(LV_{nz}\middle|SE_{nz},LV_{nm};\alpha_z,\vartheta_m,\sigma_{wz}\right)=\frac{1}{\sigma_{wz}}\phi\left(\frac{LV_{nz}-\left(\alpha_z SE_n'+\sum_{m\neq z}\vartheta_m LV_{nm}\right)}{\sigma_{wz}}\right) \quad (5)$$

$$f_{LV}\left(I_{nz}\middle|LV_{nz};\gamma_z,\zeta_Z,\sigma_{vz}\right)=\frac{1}{\sigma_{vkz}}\phi\left(\frac{I_{nz}-\left(\gamma_{kz}+\zeta_z LV_{nz}\right)}{\sigma_{vz}}\right) \quad (6)$$

where,

ϕ: is the standard normal distribution function.

Meanwhile, the choice probability is presented in Eq. 7:

$$P_{nj} = \int_{\omega} P_{njz}\left(LV_{nz}\left(\omega_{nz}\right)\right) f_{LV}\left(\omega_{nz}\right) f_{I}\left(LV_{nz}\left(\omega_{nz}\right)\right) f\left(\omega\right) d\omega \quad (7)$$

The parameters of the different parts of the HCM-analysis (structural equation and the parameters of the choice model) are jointly estimated with a full information estimation using PythonBiogeme (Bierlaire 2016).

5. Model estimation

In this section, we report the results of the estimation of a hybrid choice model, accounting for the link between the measures of Norm-Activation Model with the modality choice. Tables 2, 3, and 4 show the estimation results for the discrete choice model part, the latent variable model part, and the measurement relationship in the latent variable model part, respectively.

As explained earlier, the choice set in the discrete choice model consists of three modality groups including multimodal car users, monomodal green users, and multimodal green users. The multimodal green users group is the reference category in the estimation. Before estimating the final HCM depicted in Fig. 3, several models, including all potential combinations of direct and indirect effects between the observed and latent variables, were also tested. We finally selected the model that comprised of the highest number of significant relations while controlling for the acceptable requirements of the fit indices. Of note, according to Table 1, variables were tested in different forms in both winter and summer models. For instance, while for the HCM related to the winter season, perceived walking time to university (*PWT_U*) in the form of a continuous variable was found to be statistically significant, for the HCM related to the summer season, the same variable in the form of a dummy ((*PWT_U_30+*) defined to be one if walking time to university is more than 30 minutes and zero, otherwise) was found significant. For the HCM related to the winter season, the log-likelihood values for the null (zero) model and a converged model were found to be -8837.3 and -6268.6, respectively. The overall fit of the final model was also found to be 0.29. Corresponding indices for modality in summer was found to be -8705.1 and -5374.8, respectively, and the overall fit was found to be 0.38.

Table 2. The discrete choice part of the HCM

Attribute		winter			summer	
	Modality group	Estimate	Robust t-test		Estimate	Robust t-test
Modal group-specific constant	Multimodal car user	-3.12	-2.86		-2.92	4.34
	Monomodal green user	0.85	3.48		1.24	2.91
AGE	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
AGE_1822	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
AGE_2336	Multimodal car user	—	—		—	—
	Monomodal green user	0.92	3.54		1.24	4.88
MALE	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		-0.63	-2.93
FEMALE	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—

Attribute		winter			summer	
	Modality group	Estimate	Robust t-test		Estimate	Robust t-test
LICENSE	Multimodal car user	—	—		0.72	3.16
	Monomodal green user	—	—		—	—
CAR_OWN	Multimodal car user	2.45	4.79		1.68	2.96
	Monomodal green user	—	—		—	—
BIKE_OWN	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		0.16	2.14
PWT_PT	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PWT_PT_05	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PWT_PT_5+	Multimodal car user	0.80	3.21		—	—
	Monomodal green user	-1.03	-2.87		—	—
PWT_U	Multimodal car user	—	—		—	—
	Monomodal green user	-0.98	-3.55			
PWT_U_010	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PWT_U_1020	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PWT_U_2030	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PWT_U_30+	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		-0.63	-2.78
PCT_U	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PCT_U_010	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PCT_U_1020	Multimodal car user	—	—		—	—
	Monomodal green user	—	—		—	—
PCT_U_20+	Multimodal car user	—	—		—	—
	Monomodal green user	-0.46	-2.61			
AC	Multimodal car user	-0.18	-.2.91		-0.76	-3.75
	Monomodal green user	—	—		—	—
AR	Multimodal car user	—	—		0.45	3.12
	Monomodal green user	—	—		—	—
PN	Multimodal car user	—	—		-0.32	-2.86
	Monomodal green user	—	—		—	—
Number of observations		310			311	
Initial log likelihood		-8837.3			-8705.1	
Final log likelihood		-6268.6			-5374.8	
Rho-square for the model		0.29			0.38	
Rho-square-bar for the model		0.30			0.39	

Table 3. The latent variable model part

Attribute	Latent variable				
	AC		AR		PN
AGE	—		—		—
AGE_1822	—		—		—
AGE_2336	0.67 (3.15)				0.92 (2.44)
MALE	—		-0.32 (-2.29)		-0.86 (3.55)
FEMALE	—		—		—
LICENSE	—		.12 (2.57)		—
CAR_OWN	-1.44 (-4.11)		—		—
BIKE_OWN	—		—		—
PWT_PT	—		—		—

Attribute	Latent variable				
	AC		AR		PN
PWT_PT_05	—		—		—
PWT_PT_5+	—		—		—
PWT_U	—		—		—
PWT_U_010	—		—		—
PWT_U_1020	—		—		—
PWT_U_2030	—		—		—
PWT_U_30+	—		—		—
PCT_U	—		—		—
PCT_U_010	—		—		—
PCT_U_1020	—		—		—
PCT_U_20+	—		—		—
AC	—		0.75 (4.26)		—
AR	—		—		0.64 (3.08)
PN	—		—		—
Random term	0.64 (8.04)		0.14 (6.84)		0.78 (11.36)

Note1. Estimated coefficients are identical for both seasons in the latent variable model; the coefficients are based on a sequential estimation in this table (not a simultaneous estimation separately for seasons).
Note2. T-statistics are shown in parentheses.

Table 4. The measurement relationship in the latent variable model part

Latent factors	Indicator	Constant			Measurement parameter			Sigma	
		Estimate	Robust t-test		Estimate	Robust t-test		Estimate	Robust t-test
AC	*NAM_2*	0.74	3.23		2.16	26.11		-0.15	-5.45
	NAM_3	-0.53	-4.77		3.13	16.93		-0.36	-13.03
	NAM_4	-0.37	-7.59		2.28	8.17		-0.31	-29.14
	NAM_5	-1.12	-4.21		1.80	12.63		-1.04	-16.07
AR	*NAM_7*	-1.02	-7.39		1.65	34.68		-0.97	-8.21
	NAM_10	-1.61	-6.40		2.10	17.53		-0.44	-6.70
	NAM_11	-0.72	-4.31		1.89	11.61		-0.82	-9.01
PN	*NAM_13*	0.13	4.12		2.12	11.36		0.19	3.66
	NAM_15	-1.13	-6.64		2.35	14.01		-0.55	-6.82
	NAM_16	-0.17	-2.98		1.46	7.07		-1.43	-14.26
	NAM_17	-2.16	-4.79		3.94	13.83		-0.27	-8.54
	NAM_18	-1.31	-7.25		3.11	24.65		-1.67	-6.21
	NAM_19	0.57	4.01		2.43	9.44		-0.84	-5.45

Note. Estimated coefficients are identical for both seasons in the latent variable model; the coefficients are based on a sequential estimation in this table (not a simultaneous estimation separately for seasons).

To give the reader an impression regarding the magnitude of the most policy-sensitive observed variables out of the demographic, socioeconomic, and situational characteristics, we also calculated the elasticity of continuous parameters. Elasticity, by definition, calculates the percentage change in the probability of choosing a modality group following a one percent change in the continuous variable of interest (Hensher et al. 2005). As for the dummy variables, we calculated the mean of share differences of modality groups because the elasticity is not interpretable (Hensher et al. 2005). Figure 5 illustrates the results of the mean of share differences for observed variables for both season-specific HCM-analyses. As elasticities might have little practical meaning when they refer to latent variables, we have reported elasticities for metric variables that are not latent (Chorus and Kroesen, 2014).

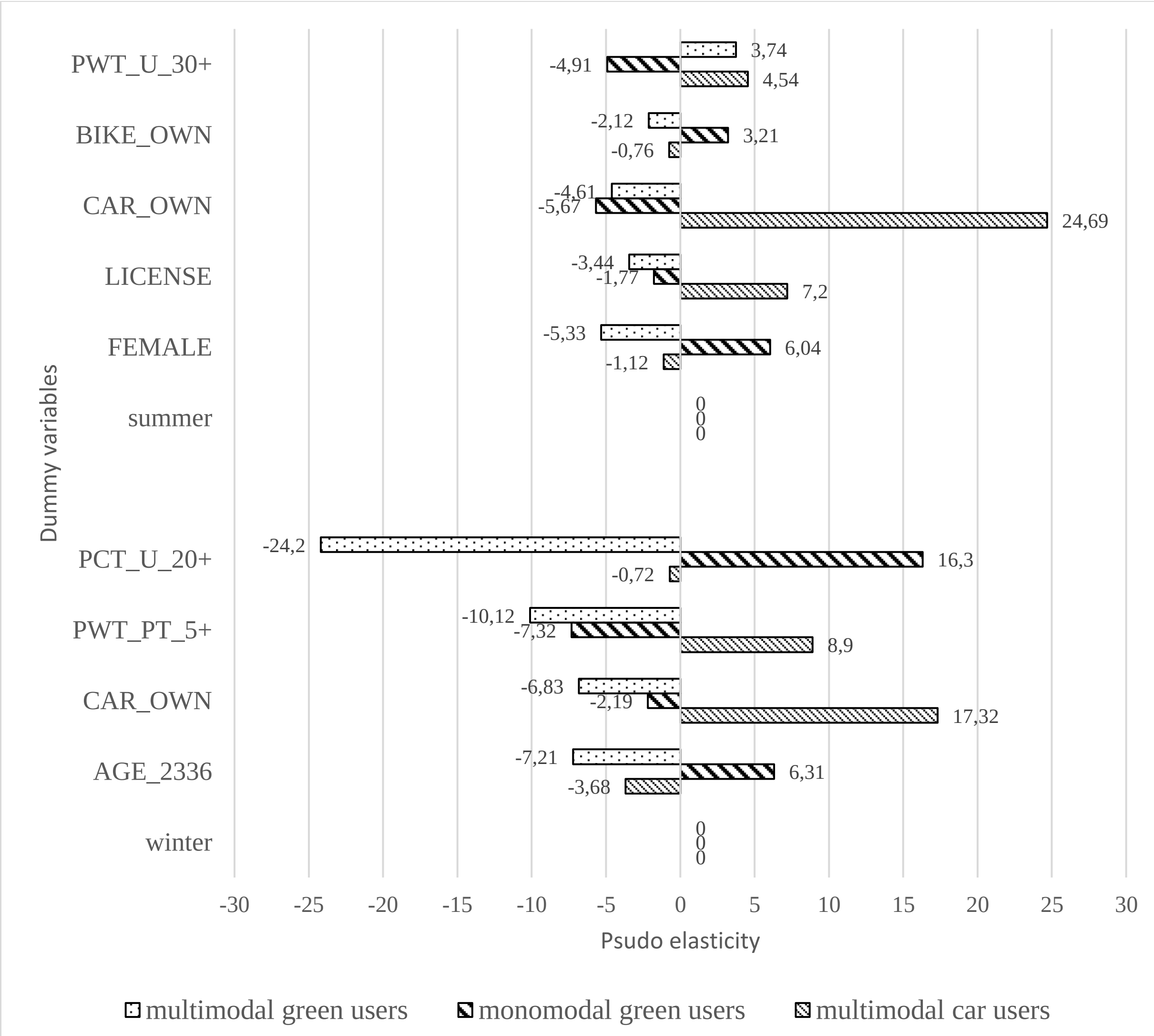


Fig 5. Share differences between categories of dummy variables in the HCMs related to winter and summer

6. Analysis of results and discussion

The following interpretations may be applied to the results. First, we found that both latent psychological variables, including the NAM components and observed variables, including socioeconomic and situational characteristics, were significant predictors of multimodality during summertime. However, in wintertime, the NAM causal chain was not significantly related to the modality use. We speculate that seasonal variation can impact on students' modality styles, due to specific weather conditions, such as snowy days, may be associated with a modal shift from monomodal or multimodal green transport modes to the occasional use of a car. Unlike previous studies which tested the NAM on mode use, we found that environmental norms and beliefs are a function of socioeconomic and situational factors. In addition, the results went beyond previous findings showing that pro-environmental behaviour with respect to modal use may rely on seasonal and situational characteristics.

Second, most of the Norwegian university students in the current study used green transport modes (Egset and Nordfjærn, 2019) rather than gasoline-based car both in winter and summer. Most of them used a single green mode, such as bus in a given season, while the rest used a combination of at least two green modes during a season. A small part of the respondents also used car, in addition to other green transport modes on their trips to and from the university. Further analysis revealed that students who were monomodal green transport users in summer were more likely to be multimodal car users during wintertime, which we conjecture might be due to unavailability of certain green modes such as high-speed bicycling paths and pavements that are often covered by snow and ice during the wintertime. For instance, students who own a bike and exclusively use it during most part of a year might have the potential to shift their current green mode (bicycle) to the car in exceptional days during the wintertime. Therefore, providing reliable and available green transport modes over the whole season (even during the exceptional weather conditions in winter), can prevent such modal shifts from green modes to car. The results also depicted that multimodal green transport users are more likely the most stable group in terms of modal shift, as they are more likely to switch their current green mode to the other green modes in exceptional cases, such as snowy days in wintertime.

Third, as for the latent psychological variables, the structural equation modeling part showed that the underlying constructs in the NAM (AC, AR, and PN) were supported by the data. In terms of the NAM causal chain, awareness of consequences (AC) was positively related to ascription of responsibility (AR), and AR was also positively related to personal norms (PN). In line with several previous studies (De Groot et al., 2008; Jakovcevic & Steg, 2013; Lind et al., 2015; Nordfjaern & Rundmo, 2015; Hiratsuka et al., 2018; Ünal et al., 2019), the behavioural link between the NAM causal chain and modal use was shown to be advocated in summer, but this link was not supported for wintertime. This finding is also supported by some previous studies (Nordfjaern and Zavareh, 2017; Mehdizadeh et al., 2019). However, a closer look at the results indicates that awareness of consequences could directly influence modality use either in summer or winter. For instance, pro-environmental awareness regarding car use consequences among students was shown to be related to less multimodal car use in summer and winter.

In contrast with several previous studies, more ascription of responsibility was shown to be related to the more occasional use of car (multimodal car users) than the other two green modality groups in summer. This relation is in the opposite direction from what is presumed by the NAM theory. Recent studies have also reported that ascription of responsibility is associated with less pro-environmental mode use in different populations (e.g. Şimşekoğlu, 2018; Lind et al., 2015). This may imply that those who currently (and occasionally) use car to and from the university feel more sense of responsibility for reducing the negative impacts of car use due to their actual behaviour, while students who tend to use green modes do not perceive a similar responsibility for the negative impacts of the gasoline-based car. This finding is in line with the self-perception theory, where individuals modify their attitudes by observations of their own behaviour (Bem, 1972). However, investigating this finding is an avenue for further research, and can give new insights into the NAM structure or the operational measurement of this specific NAM dimension. On the other hand, and in agreement with previous studies, those who reported stronger personal norms and obligations about the environment tended to be monomodal green users and less likely to be a multimodal car user during summertime.

The analysis further showed that females are more likely to have a stronger awareness of consequences and personal moral obligation concerning car use reduction. Similarly, students who were older than 23 years tended to report a pro-environmental personal norms and awareness of consequences. Therefore, policy and measures could target the younger students and males.

Fourth, regarding the correlates of multimodality among demographic and socioeconomic variables, the results showed that students' age did not seem to significantly impact multimodal car use either in winter or summer. In accordance with previous multimodality studies (Buehler and Hamre, 2015; Heinen and Chatterjee, 2015), we found that older students were more likely to be monomodal green transport users in wintertime. We speculate that due to more experience and habit formation, older students had already shaped their modality style with respect to a specific green mode than freshman students. The share of monomodal green use among students who were older than 23 years was 6.31% higher than those who were between 19 and 23 years old. Unlike previous studies (e.g. Mehdizadeh and Ermagun, 2018; Scheiner et al. 2016), a noticeable gender gap on multimodality behaviour was not found in the current study. However, the findings showed that males were more likely to be monomodal green transport users during summertime. The share of monomodal green transport use for males was 6.04% lower than for females.

Unsurprisingly, there was a significant correlation between car ownership and occasional use of car both in winter and in summer. This is consistent with what has been found in previous studies (e.g. Molin et al., 2016; Diana and Mokhtarian, 2009). The share of multimodal car use for students who own at least one car is 24.69% and 17.32% greater than other students in summer and winter, respectively. Due to the relatively low-income among students and relatively expensive prices of cars in Norway we cannot exclude the possibility that most of the university students would have occasionally used cars to university if this alternative was economically feasible to them. Entailing push and pull measures with the aim to promote this large group of young adults to continue their choices of green modes is a fundamental challenge for policymakers even after their graduation from the university. Unlike some prior studies, holding a driving license was not found as a significant correlate of multimodality during wintertime, while this variable had a positive impact on multimodal car use in summer. The share of multimodal car use for students who hold a driving license was 7.20% higher than those who did not have a driving license.

Fifth, regarding the correlates of multimodality and monomodality with respect to the situational variables, perceived walking time to the university (*PWT_U*) (as a proxy of distance from the residential location to the university) was found to be a significant barrier of monomodal green transport use during both seasons. The elasticity results showed that a 1% increase in walking time to the university decreased the share of monomodal green transport use in the wintertime by 0.84%, while this increment increased the share of multimodal car use and multimodal green transport use by 0.51% and 0.06% in the same season, respectively. Besides, the share of monomodal green use in summer among those who had more than 30 minutes walking time to the university was 4.91% lower than other students. This finding is aligned with previous studies wherein distance has been reported as an important barrier to walking and cycling (Kuhnimhof et al., 2006; Mehdizadeh et al., 2018). Furthermore, the results revealed that the perceived walking time to the nearest public transit station (*PWT_PT*) on trips to the university and perceived cycling time to the university (*PCT_U*) play significant roles in modality use during wintertime than summertime. A potential explanation for the stronger importance of situational variables in wintertime than the summertime could be found in the weather conditions in Norway. A longer distance may be positively related to more exposure to cold weather. For instance, in Trondheim, the average temperatures varied between -3.5°C in February and -2.6°C in March to 17.3°C in July and 13.1°C in August 2018 (Yr, 2018). The winters are rather long lasting starting from late October with a duration through March. Snowy conditions combined with low temperature may challenge the use of active transportation, such as cycling and walking during the winter season. Under such circumstances, situational factors (e.g. distance to the university and availability of public transportation) may play more important roles in choosing the mode of travel, rather than psychological processes (e.g. the NAM) underlying the decision-making process. Norms and beliefs may be important only when the individuals are allowed to act in accordance with the environment (Mehdizadeh et al., 2019). Therefore, green transport policies related to environmental norms could be implemented according to season. While situational features could be intervened in wintertime, campaigns could focus on psychological factors during summertime.

7. Summary and conclusions

This study contributed to the literature by investigating the relative roles of environmental norms and beliefs and socioeconomic and situational variables on multimodal and monomodal green transport and car use among a sample of Norwegian university students across winter and summer. The norm-activation model (NAM) was used to examine the structural relationships of awareness of consequences, the ascription of responsibility, and personal norms on modal choice. We also developed a hybrid choice model (HCM) to simultaneously incorporate several latent variables and observable variables in an integrated discrete choice model. In other words, we extended the NAM theory by investigating the mediating effects of the NAM components in the relation between socioeconomic, situational characteristics, and modality groups as well as several direct effects.

Understanding how, and to what extent, either psychological environmental beliefs or situational factors contribute in monomodal and multimodal use of green modes or car among younger adults, such as university students, across two different seasons may have policy and planning implications.

First, we found that students' environmental beliefs and norms can play an important role in the decision processes underlying their modality use when different green modes are available and feasible, even in exceptional cases such as rainy and snowy days. The study revealed that the NAM was associated with green mode use in the summertime, while this relation was not supported for wintertime. Policymakers could implement measures so as to provide availability of all sustainable transport modes and routes, such as bicycle paths, and reliable and safe walking paths, for all days during wintertime even in days with heavy snow fall in order to activate individuals' moral obligations towards reducing car use and modal shifts from car to green transport modes. Push and pull policies could bring effective practices to reduce any shift from green transport modes to car. Campaigns designed to raise public support in the use of green transport could elicit socially desirable behaviours related to green mode use. Messages could be conveyed through pre-designed events at the university campuses or on the university websites and pages. For instance, getting the students' awareness more enhancing regarding the environmental consequences of their behaviour, creating campaigns with goals to elicit the sense that the students need to ascribe more responsibility in dealing with environment and that they feel morally obliged in preserving the environment could be some relevant messages. On the other hand, in order to reduce car use among students, especially in seasons with mild weather conditions, push measures such as increased on-site campus parking fees or entrance fees at the gates may work as tools to discourage the students from putting the car in their modality choice set.

Second, although it seemed that most of the students in the current sample were green transport-oriented, around 60% of them exclusively used a single mode of green transport both in winter and summer. In particular, among those who were monomodal green users, 31% exclusively used active transportation modes in winter, while 47% of them used this mode in summer. This may also highlight that active transportation mode, such as walking and cycling, may be infeasible during some days in wintertime. Therefore, a number of students may shift their dominant green mode (e.g. bicycling) to car in wintertime due to the infeasibility and inconvenience of other green modes, such as walking. Encouraging students to be multimodal green transport users could be a feasible policy in order to reduce the probability of any shift from a green-oriented mode to the car even in days with exceptional weather during the winter season. Universities with their social environments are suitable places for promoting and implementing policies related to sustainable transport. Most students are open-minded and receptive to new ideas from different campaigns, where the aim is to orient students' travel behaviour towards green modal choices. It may be helpful to launch transport campaigns at universities to highlight the benefits of multimodal green transport use, especially during days with difficult weather conditions in wintertime. For instance, some new programmes such as the Mobility as a Service (MaaS) plan (Matyas and Kamargianni, 2018) can be utilized to motivate university students to subscribe to a certain amount of each green transportation service (e.g., public transit, car sharing) for some exceptional days during wintertime. At the same time, transportation and university authorities could provide physical transportation facilities to serve certain goals and policies of the campaigns. To do this, arranging a shared mobility programme for heavy snowy or cold days can prevent any shift of active-oriented users to occasional use of a private car.

Third, we found that situational characteristics played an integral part in students' modality use during wintertime than summertime. This finding supported the assumption that weather conditions can alter the behavioural mechanisms underlying the mode choice decision processes. A longer distance from home to the university and the lack of a good accessibility to public transit may pose a challenge to sustainability in countries with a cold climate, especially during wintertime. Therefore, providing a feasible, reliable and integrated public transit (e.g. bus, tram) as well as keeping pavements and bicycling paths free from snow and ice in wintertime can prevent a modal shift from green modes to the car.

Future investigations are necessary to validate the conclusions drawn from this study. First our empirical findings herein are limited to a single dataset. A library of empirical evidence from other countries is required before any decisive conclusion about the transferability of the findings can be made. Second, our data relyed on a cross-sectional survey; however, this method is common in investigating the NAM and mode use in previous studies. Third, the data did not include traditional attributes (travel time or costs) of specific mode alternatives. However, we tested walking and cycling time to university as a proxy measure of travel time/distance in the hybrid choice model. In addition, we measured the environmental beliefs and norms by the norm activation model (NAM). Future studies could use the value-belief-norm (VBN) theory, which includes more nuances and may be termed as an extended version of the NAM, which contains values and ecological worldview scales as well as the NAM components (Jansson et al., 2011; Nordlund et al., 2018; Stern et al., 1999; Stern et al., 1995; Westin et al., 2018; Wolske et al., 2017). However, there are two main reasons that we still believe that the NAM theory is important in order to obtain a better understanding of students' norm activation systems and how these relate to mode use in the present study. First, the "values" and "ecological worldviews" are very difficult to amend, as they are stable and change resistant. Next, to test our complex frameworks (via HCM-analysis), parsimony and simplicity are advantageous. We did not aim to deeply focus on the exclusive role of a more complex environmental theory, such as the VBN.

Finally, we applied a self-reported study which may be susceptible to socially desirable responding. Future studies could fruitfully tackle this issue by collecting a more extensive database, for instance, by incorporating real mode use data through smartphone data or GPS.

References

Abrahamse, W., Steg, L., Gifford, R., & Vlek, C. (2009). Factors influencing car use for commuting and the intention to reduce it: A question of self-interest or morality?. Transportation Research Part F: Traffic Psychology and Behaviour, 12(4), 317-324.

Ajzen, I. (1991). The theory of planned behavior. Organizational behavior and human decision processes, 50(2), 179-211.

Bamberg, S., & Schmidt, P. (2003). Incentives, morality, or habit? Predicting students' car use for university routes with the models of Ajzen, Schwartz, and Triandis. Environment and behavior, 35(2), 264-285.

Bem, D. J. (1972). Self-perception theory. In Advances in experimental social psychology (Vol. 6, pp. 1-62). Academic Press.

Ben-Akiva, M., McFadden, D., Train, K., Walker, J., Bhat, C., Bierlaire, M., ... & Daly, A. (2002). Hybrid choice models: progress and challenges. Marketing Letters, 13(3), 163-175.

Bierlaire, M. (2016). Estimating choice models with latent variables with PythonBiogeme (No. REP_WORK).

Bratt, C. (1999). The impact of norms and assumed consequences on recycling behavior. Environment and behavior, 31(5), 630-656.

Buehler, R., & Hamre, A. (2013). Trends and determinants of multimodal travel in the USA (No. VT-2012-09). Mid-Atlantic Universities Transportation Center.

Buehler, R., & Hamre, A. (2015). The multimodal majority? Driving, walking, cycling, and public transportation use among American adults. Transportation, 42(6), 1081-1101.

Buehler, R., & Hamre, A. (2016). An examination of recent trends in multimodal travel behavior among American motorists. International journal of sustainable transportation, 10(4), 354-364.

Cervero, R., Sarmiento, O. L., Jacoby, E., Gomez, L. F., & Neiman, A. (2009). Influences of built environments on walking and cycling: lessons from Bogotá. International journal of sustainable transportation, 3(4), 203-226.

Cherchi, E. (2017). A stated choice experiment to measure the effect of informational and normative conformity in the preference for electric vehicles. Transportation Research Part A: Policy and Practice, 100, 88-104.

Cherchi, E., Meloni, I., & Ortúzar, J. D. D. (2013). The latent effect of inertia in the choice of mode. In 13th International Conference on Travel Behavior Research, Toronto, Canada.

Chorus, C. G., & Kroesen, M. (2014). On the (im-) possibility of deriving transport policy implications from hybrid choice models. Transport Policy, 36, 217-222.

Chlond, B. (2012). Making People Independent from the Car–Multimodality as a Strategic Concept to Reduce CO 2-Emissions. In Cars and Carbon (pp. 269-293). Springer, Dordrecht.

Danaf, M., Abou-Zeid, M., & Kaysi, I. (2014). Modeling travel choices of students at a private, urban university: insights and policy implications. Case studies on transport policy, 2(3), 142-152.

De Groot, J. I., Steg, L., & Dicke, M. (2008). Transportation trends from a moral perspective: Value orientations, norms and reducing car use. New transportation research progress, 67-91.

Diana, M., & Mokhtarian, P. L. (2009). Desire to change one's multimodality and its relationship to the use of different transport means. Transportation Research Part F: Traffic Psychology and Behaviour, 12(2), 107-119.

Diana, M. (2008). Making the "primary utility of travel" concept operational: a measurement model for the assessment of the intrinsic utility of reported trips. Transportation research part A: policy and practice, 42(3), 455-474.

Egset, K. S., & Nordfjærn, T. (2019). The role of transport priorities, transport attitudes and situational factors for sustainable transport mode use in wintertime. Transportation Research Part F: Traffic Psychology and Behaviour, 62, 473-482.

Fyhri, A., & Hjorthol, R. (2009). Children's independent mobility to school, friends and leisure activities. Journal of transport geography, 17(5), 377-384.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). Applied choice analysis: a primer. Cambridge University Press.

Heinen, E., & Chatterjee, K. (2015). The same mode again? An exploration of mode choice variability in Great Britain using the National Travel Survey. Transportation Research Part A: Policy and Practice, 78, 266-282.

Hiratsuka, J., Perlaviciute, G., & Steg, L. (2018). Testing VBN theory in Japan: Relationships between values, beliefs, norms, and acceptability and expected effects of a car pricing policy. Transportation research part F: traffic psychology and behaviour, 53, 74-83.

Hyland, M., Frei, C., Frei, A., & Mahmassani, H. S. (2018). Riders on the storm: Exploring weather and seasonality effects on commute mode choice in Chicago. Travel behaviour and society, 13, 44-60.

Huijts, N. M. A., De Groot, J. I. M., Molin, E. J. E., & Van Wee, B. (2013). Intention to act towards a local hydrogen refueling facility: Moral considerations versus self-interest. Transportation Research Part A: Policy and Practice, 48, 63-74.

Jakovcevic, A., & Steg, L. (2013). Sustainable transportation in Argentina: Values, beliefs, norms and car use reduction. Transportation Research Part F: Traffic Psychology and Behaviour, 20, 70-79.

Jansson, J., Marell, A., & Nordlund, A. (2011). Exploring consumer adoption of a high involvement eco-innovation using value-belief-norm theory. Journal of Consumer Behaviour, 10(1), 51-60.

Joireman, J. A., Lasane, T. P., Bennett, J., Richards, D., & Solaimani, S. (2001). Integrating social value orientation and the consideration of future consequences within the extended norm activation model of proenvironmental behaviour. British Journal of Social Psychology, 40(1), 133-155.

Kim, J., Rasouli, S., & Timmermans, H. J. (2017). The effects of activity-travel context and individual attitudes on car-sharing decisions under travel time uncertainty: A hybrid choice modeling approach. Transportation Research Part D: Transport and Environment, 56, 189-202.

Khattak, A., Wang, X., Son, S., & Agnello, P. (2011). Travel by university students in Virginia: Is this travel different from travel by the general population?. Transportation Research Record, 2255(1), 137-145.

Kuhnimhof, T., Chlond, B., & Von Der Ruhren, S. (2006). Users of transport modes and multimodal travel behavior: Steps toward understanding travelers' options and choices. Transportation Research Record, 1985(1), 40-48.

Kuhnimhof, T., Buehler, R., Wirtz, M., & Kalinowska, D. (2012). Travel trends among young adults in Germany: increasing multimodality and declining car use for men. Journal of Transport Geography, 24, 443-450.

Matyas, M., & Kamargianni, M. (2018). The potential of mobility as a service bundles as a mobility management tool. Transportation, 1-18.

Mehdizadeh, M., Nordfjaern, T., & Mamdoohi, AR. (2019). Environmental norms and sustainable transport mode choice on children's school travels: The norm-activation theory, International Journal of Sustainable Transportation, DOI: 10.1080/15568318.2018.1532542

Mehdizadeh, M., & Ermagun, A. (2018). "I'll never stop driving my child to school": on multimodal and monomodal car users. Transportation, 1-32. DOI: https://doi.org/10.1007/s11116-018-9949-5

Molin, E., Mokhtarian, P., & Kroesen, M. (2016). Multimodal travel groups and attitudes: A latent class cluster analysis of Dutch travelers. Transportation Research Part A: Policy and Practice, 83, 14-29.

Møller, M., Haustein, S., & Bohlbro, M. S. (2018). Adolescents' associations between travel behaviour and environmental impact: A qualitative study based on the Norm-Activation Model. Travel Behaviour and Society, 11, 69-77.

Muromachi, Y. (2017). Experiences of past school travel modes by university students and their intention of future car purchase. Transportation Research Part A: Policy and Practice, 104, 209-220.

Nobis, C. (2007). Multimodality: facets and causes of sustainable mobility behavior. Transportation Research Record, 2010(1), 35-44.

Nordfjærn, T., & Zavareh, M. F. (2017). Does the value-belief-norm theory predict acceptance of disincentives to driving and active mode choice preferences for children's school travels among Chinese parents?. Journal of Environmental Psychology, 53, 31-39.

Nordfjærn, T., Egset, K. S., & Mehdizadeh, M. (2019). “Winter is coming”: Psychological and situational factors affecting transportation mode use among university students. Transport Policy.

Nordlund, A. M., & Garvill, J. (2003). Effects of values, problem awareness, and personal norm on willingness to reduce personal car use. Journal of environmental psychology, 23(4), 339-347.

Nordlund, A., Jansson, J., & Westin, K. (2018). Acceptability of electric vehicle aimed measures: Effects of norm activation, perceived justice and effectiveness. Transportation Research Part A: Policy and Practice, 117, 205-213.

Limanond, T., Butsingkorn, T., & Chermkhunthod, C. (2011). Travel behavior of university students who live on campus: A case study of a rural university in Asia. Transport policy, 18(1), 163-171.

Lind, H. B., Nordfjærn, T., Jørgensen, S. H., & Rundmo, T. (2015). The value-belief-norm theory, personal norms and sustainable travel mode choice in urban areas. Journal of Environmental Psychology, 44, 119-125.

Scheiner, J., Chatterjee, K., & Heinen, E. (2016). Key events and multimodality: A life course approach. Transportation Research Part A: Policy and Practice, 91, 148-165.

Schwartz, S. H. (1977). Normative influences on altruism. In Advances in experimental social psychology (Vol. 10, pp. 221-279). Academic Press.

Simsekoglu, Ö. (2018). Socio-demographic characteristics, psychological factors and knowledge related to electric car use: A comparison between electric and conventional car drivers. Transport Policy, 72, 180-186.

Simsekoglu, Ö., & Klöckner, C. A. (2018). The role of psychological and socio-demographical factors for electric bike use in Norway. International Journal of Sustainable Transportation, 1-9.

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. Journal of environmental psychology, 29(3), 309-317.

Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. Human ecology review, 81-97.

Stern, P. C., Kalof, L., Dietz, T., & Guagnano, G. A. (1995). Values, beliefs, and proenvironmental action: Attitude formation toward emergent attitude objects 1. Journal of applied social psychology, 25(18), 1611-1636.

Thorhauge, M., Cherchi, E., Walker, J. L., & Rich, J. (2017). The role of intention as mediator between latent effects and behavior: application of a hybrid choice model to study departure time choices. Transportation, 1-25.

Tyler, T. R., Orwin, R., & Schurer, L. (1982). Defensive denial and high cost prosocial behavior. Basic and Applied Social Psychology, 3(4), 267-281.

Ünal, A. B., Steg, L., & Granskaya, J. (2019). "To support or not to support, that is the question". Testing the VBN theory in predicting support for car use reduction policies in Russia. Transportation Research Part A: Policy and Practice, 119, 73-81.

Verplanken, B., Aarts, H., & Van Knippenberg, A. (1997). Habit, information acquisition, and the process of making travel mode choices. European journal of social psychology, 27(5), 539-560.

Verplanken, B., & Orbell, S. (2003). Reflections on past behavior: a self-report index of habit strength 1. Journal of applied social psychology, 33(6), 1313-1330.

Westin, K., Jansson, J., & Nordlund, A. (2018). The importance of socio-demographic characteristics, geographic setting, and attitudes for adoption of electric vehicles in Sweden. Travel Behaviour and Society, 13, 118-127.

Whalen, K. E., Páez, A., & Carrasco, J. A. (2013). Mode choice of university students commuting to school and the role of active travel. Journal of Transport Geography, 31, 132-142.

Wolske, K. S., Stern, P. C., & Dietz, T. (2017). Explaining interest in adopting residential solar photovoltaic systems in the United States: Toward an integration of behavioral theories. Energy research & social science, 25, 134-151.

Yr. (2018). Weather statistics for Trondheim (Trøndelag). Retrieved 26.10.18 from: https://www.yr.no/place/Norway/Tr%C3%B8ndelag/Trondheim/Trondheim/statistics.html